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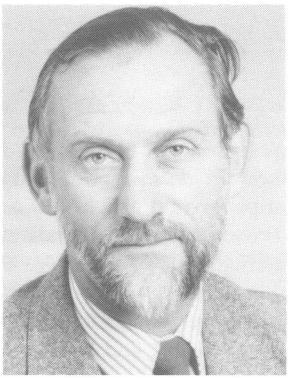
OIKOS 77: 378–380. Copenhagen 1996

John Lawton's View from the Park 18



Nessiteras rhombopteryx

Nessiteras rhombopteryx is the scientific name assigned to Nessie, the Loch Ness monster, by Sir Peter Scott and Robert Rines in an article in *Nature* (258: 466–468, 1975). The first report of a monster in Loch Ness apparently dates to the time of St. Columba's visit in 565 AD and it is now one of the world's favourite and most famous monsters (see M. Burton *The Elusive Monster* Hart-Davis, 1961). As in all good monster stories, numerous people claim to have seen it, some of them whilst stone-cold sober. Scott and Rines named it on the basis of strobe-flash photographs taken at depths between 10 and 15 m with a time-lapse camera. Two of the photographs show a large, paddle-like fin and part of the animal's back and belly, the third is of the creature's head, neck and part of its body. Accompanying sonar traces suggest a large animal, some 15–20 m in length, including a long, sinuous neck. The photographs were 'computer enhanced', but are nevertheless very fuzzy. An artist's reconstruction in their *Nature* paper depicts a big, dumpy, plesiosaur-like creature, although Scott and Rines are careful not to speculate as to its affinities, beyond suggesting that it is reptilian. Its scientific name, incidentally, roughly translates as the Ness monster with diamond fin.

Human beings seem to have a deep-seated desire to believe in strange and elusive creatures. We simultaneously love and fear them – be they dragons, sea-serpents or unicorns. They are often humanoid (the Yeti in the Himalayas, Big Foot in North America, and Bunyip in Australia), but Dinosaur-mania in children is a manifestation of the same phenomenon. In the world in which primitive *Homo sapiens* evolved, a healthy fear of, but fascination with, strange and unfamiliar animals was undoubtedly wise. I would not be at all surprised if our modern infatuation with monsters has a genetic basis. But as the world has shrunk, the notion that there are numerous large, unknown creatures out there, over the next hill, or deeper into the forest has become more and more difficult to sustain rationally. Rationality, however, has little to do with it. The fears and beliefs are very real, and run very deep. I have two friends in Cameroon with whom I have worked closely for five years. Both are well educated, both speak three or four languages and one of them has a good honours degree in philosophy. They work with me in the forest every day without any problems, but they absolutely refuse to go into the forest with me at night. At night, they insist, the forest is re-inhabited by all the large animals that have gone from this part of Cameroon (elephants, gorillas, lions) and some that were never there (including a monster that is half tree, half man). No degree of rational argument will persuade them otherwise. The forest at night is a fearful place.

So rationally, is there a Loch Ness monster? One could argue that if *Nature*, a pillar of the scientific establishment believes it, then it must be true, mustn't it? After all, Scott and Rine's article appeared on 11 December, not 1 April (All Fools' Day). One reason for publishing it, they claim, was to afford legal protection to the creature; under UK law, a species can only be protected if it has a scientific and common name. So Nessie is now safe. We can photograph it, but not shoot it. But can we make a better job than fuzzy, computer enhanced images of trying to establish whether there really is a monster in Loch Ness, and if so, how many? Answering this question is a fascinating, albeit slightly bizarre exercise in the application of ecological theory. Who said ecology is not a predictive science?

First, we need some background. Loch Ness is not small. It is nearly 40 km long, up to 2.5 km wide, and over 200 m deep over much of its length, with a maximum depth of nearly 300 m. It has a surface area of about 5700 ha and a volume of 7.52×10^9 m^3.

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Several double-decker buses sunk on the bottom would be hard to find. For a brief period after the last glaciation the loch may have been an arm of the sea, although it is now 15 m above sea-level, and connected to the sea by a river that will not accommodate anything much bigger than a seal. If a monster, or monsters, entered the loch from the sea after the last glaciation it, or they, have survived for about 12 000 years. Several strands of ecological theory can be brought to bear on the question of whether one or more large creatures are likely to have survived in isolation in Loch Ness for this period of time. I make no claims for any originality in these arguments. They are all in the literature, but deserve to be better known.

The first line of argument is to use the basic rules of energy flow and trophic dynamics. R. W. Sheldon and S. R. Kerr did this in *Limnology and Oceanography* (17: 796–798, 1972; see also 18: 345–346, 1973), bringing together several strands of theory and data. They suggest, and I agree, that if Nessie exists, it feeds on fish. The first thing they therefore did was to work out, using the best available data at the time, the likely productivity of fish in this deep, oligotrophic water body. Then, using their own work on biomass distributions for oceanic organisms of different body-sizes, and assuming that similar relationships hold for large fresh-water bodies, they suggest that the total biomass of monsters in the loch is probably in the range 3135–15 675 kg. If adults weigh a minimum of 100 kg ('anything smaller is not suitably monstrous'), then there are between 1 and 156 individuals. Narrowing this down, monsters of average length 8 m (smaller than the one illustrated by Scott and Rines) must weigh about 1500 kg, suggesting that there are unlikely to be more than 2–10 individuals; Sheldon and Kerr plump for something a bit smaller, and come up with 10–20 individuals if there is a breeding population, including babies. Finally, if the monster population feeds on fish, with an ecological efficiency typical of ectotherms (i.e. about 10%), and if monsters consume a major part of the fish production in the loch, their production is of the order of 300 kg $year^{-1}$. In a stable population, this would generate about three dead 100-kg monsters per year. As Sheldon and Kerr point out, 'larger monsters would die less frequently', nicely explaining why the shores of Loch Ness are not littered with the corpses of rotting Nessies, although in a reply to Sheldon and Kerr, C. H. Mortimer wondered why 'no tooth or scale, no bone or skin, no tangible trace [has] come to light over the centuries?'

Mortimer missed the point. Sheldon and Kerr's article is interesting irrespective of whether there are, or are not, monsters in Loch Ness, because it tackles an important general question in an amusing and novel way, using sound ecological data and theory. Nearly 25 years later, we could do a tighter job, but the underlying theoretical principles would be the same. It would be instructive, for example, to use the enormous body of data and theory brought together by Daniel Pauly and colleagues (*Nature* 374: 255–257, 1995) to fix fish and monster production much more precisely. We could also do a Minimum Viable Population analysis, although getting some sense of the magnitude of population fluctuations for a creature like Nessie would require creative lateral thinking. However (as Stuart Pimm has pointed out) because populations of large-bodied species tend to fluctuate less on an annual basis than small-bodied species, and because adult Nessies are very large, a population of even 10 individuals might have a fighting chance of surviving for 12 000 years, although I hate to think what the level of inbreeding depression might be.

As in all theoretical speculations it is a good idea to see if a completely different set of assumptions gives the same, or a similar, answer. There have been at least two attempts to do this. W. Scheider and P. Wallis (*Limnology and Oceanography* 18: 343, 1973) used data on particle densities in unproductive oceanic waters to estimate that there are between 150 small monsters and 10 large ones. And in a second, very different approach, Carl Sagan (*Nature* 264: 497, 1976) applied collision theory (derived from physics) to the problem. Sagan estimated that on the basis of the 1975 survey underpinning Scott and Rines's article, scientists deliberately hunting Loch Ness monsters encounter them about every 10^4 to 10^5 seconds. Guestimating body size, speed of movement and maximum detection distance for monsters, and assuming that they are neither attracted to, nor repelled by the observers, Sagan estimates conservatively that the population is of order 300, ranging from as little as 10 to a likely maximum of 1000. This method of estimating the likely population size of rare animals has not, apparently, been used by ecologists (it is not cited by Charles Krebs, for example, in *Ecological Methodology*, Harper & Row, 1989), but it clearly has potential. In this case, the numbers it comes up with are reassuringly close to those obtained by Sheldon and Kerr, and by Scheider and Wallis.

What other independent methods might we employ, that were not available in the early 1970s? One approach would be to use the now well established positive relationship between population abundance and size of geographic range within related taxa – geographically restricted species tend to occur at lower population densities than geographically widespread species. Nessie has a very restricted range, and therefore it must occur at low densities. Qualitatively, at least, this is consistent with the older predictions. To do better, we need data on population densities for similar taxa. For example, for a given size of geographic range, British mammals have population densities about 30 times higher than British birds, but with an otherwise identical slope to the abundance:range-size graph (T. Blackburn et al. unpublished manuscript). (Here, incidentally is a real mystery – why do both these patterns exist?). In the absence of good data

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on the population densities of other monsters, we will have to use the next best thing, large reptiles for example. I do not propose to do the calculation here, or to labour all the niceties that we might have to incorporate (diet, body-size, environmental productivity, etc.) but you get the point. It could be done.

None of this is to be taken too seriously, but it does have a serious side to it. Too often we lament the fact that ecological science lacks predictive power. As I have said before in these essays, it depends what it is we seek to predict, and with what degree of accuracy. Ecology is no better or worse than many other sciences at predicting order-of-magnitude phenomena. We can bring a nice array of empirical data and theoretical understanding to predict the likely population size of a mythical beast. What one cannot do, in this particular case, is refute the predictions. Why not? The detectives among you will probably have realised that the 11 December issue of *Nature* was the Christmas 1975 issue, and those of you who are good at crosswords may have noticed an interesting thing about the scientific name of the Ness monster with diamond fin. *Nessiteras rhombopteryx* is an anagram. Unscrambled, it spells out 'monster hoax by Sir Peter S'.

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